

# HYDROGEN: THE NEXT GENERATION

DISCOVER CUMMINS ELECTROLYZER  
TECHNOLOGIES

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**H**

Hydrogen  
1.00794

FOR  
A WORLD  
THAT'S  
ALWAYS ON™



#GENERATIONH

# WE'RE AT THE HEART OF THE POWER REVOLUTION

Cummins has a 100-year history rooted in innovation. We transformed diesel into an everyday power source. Today, we're a technology business with diverse power solutions for every need, with 10,000 of the world's brightest engineering minds focused on the future. Hydrogen has a major role in clean power, industry, and mobility, as we look to the next 100 years.

### OUR RESEARCH AND TECHNOLOGY COMMITMENT

Annual spend \$1bn to advance power technologies. Integration expertise to help manufacturers define the best power source for their applications and equipment.

### INNOVATION LEADERSHIP

Breakthrough innovations in Proton Exchange Membrane (PEM) technology. Leading the way in hydrogen generation at megawatt (MW) scale.

### BEST TOTAL COST OF OWNERSHIP

Advanced technology with high efficiency, lower maintenance costs and fit-and-forget reliability delivers unrivalled lifetime value.



### SPECIALIST HYDROGEN KNOWHOW

More than 70 years of hydrogen leadership. Over 600 electrolyzers in 100 countries worldwide.

### IMPECCABLE SAFETY RECORD

Zero significant safety breaches in decades of use.

### GLOBAL REACH

Cummins has the global resources to support your hydrogen project, no matter how big and no matter where.

### UNLIMITED PEACE OF MIND

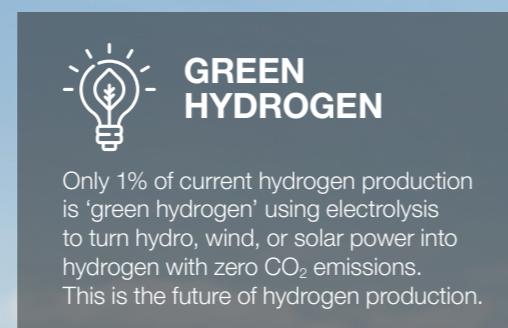
Cummins is your long-term partner into the hydrogen future.

# THIS IS #GENERATIONH

**Green hydrogen from water is the next generation solution, for generations to come.**

As the world heads on its challenging journey towards decarbonization, the role of clean hydrogen is mission critical. Yet today, some 95% of the world's hydrogen is still produced from fossil fuels.

Green hydrogen is the future, and Cummins is one of the few global companies with expertise across both critical technologies – clean zero-carbon hydrogen generation through both primary electrolysis technologies, and the fuel cell technology that the future of power depends on. We're at the heart of the new hydrogen economy. However large or small your hydrogen ambitions and however hydrogen fits into your future, Cummins is ready to support you today. **Welcome to GENERATION H.**

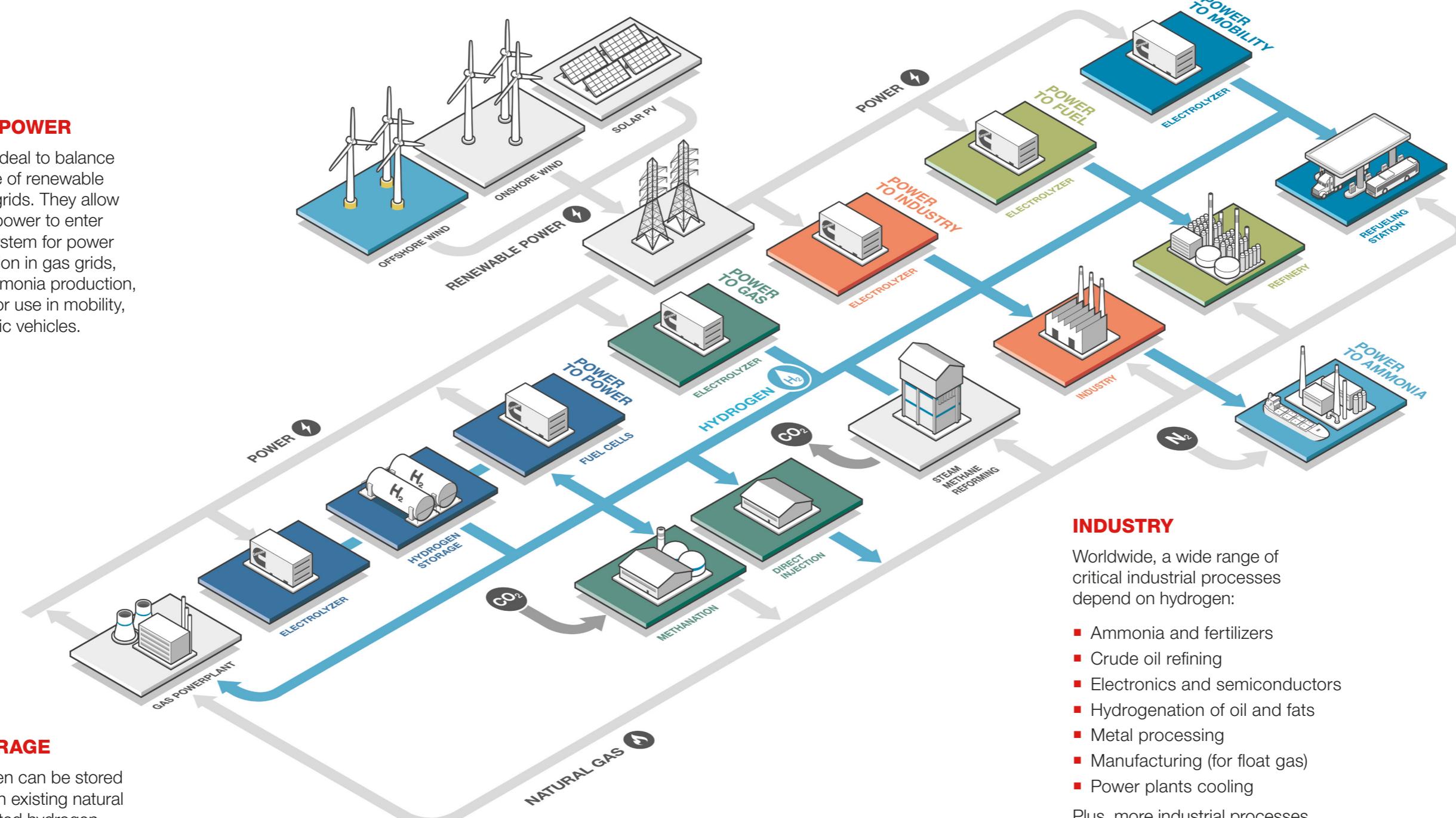


# TOWARDS ZERO CARBON POWER THE GREEN HYDROGEN ECONOMY

Hydrogen produced from renewable power through advanced electrolysis technology is the key to unlocking a cleaner and more sustainable future.

## RENEWABLE POWER

Electrolyzers are ideal to balance the growing share of renewable energy in power grids. They allow more renewable power to enter into the energy system for power production, injection in gas grids, industrial use, ammonia production, renewable fuels, or use in mobility, like fuel cell electric vehicles.



## ENERGY STORAGE

As a gas, hydrogen can be stored and transported in existing natural grids or in dedicated hydrogen pipelines, to support the storage of renewable energy in large quantities and the decarbonization of a variety of applications.

## MOBILITY

Hydrogen is at the start of its journey towards playing a pivotal role in the future of mobility worldwide. Hydrogen is produced on-site in hydrogen refueling stations to refuel light (passenger cars) and heavy-duty (trains, trucks and buses) fuel cell electric vehicles.

## INDUSTRY

Worldwide, a wide range of critical industrial processes depend on hydrogen:

- Ammonia and fertilizers
- Crude oil refining
- Electronics and semiconductors
- Hydrogenation of oil and fats
- Metal processing
- Manufacturing (for float gas)
- Power plants cooling

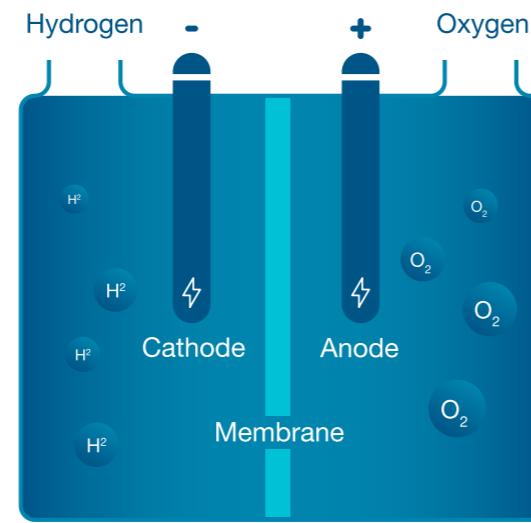
Plus, more industrial processes are being converted to hydrogen to reduce CO<sub>2</sub> emissions such as in steel making or industrial heat.

## THE ESSENTIALS OF ELECTROLYSIS

**At the heart of Cummins' hydrogen generation technology is electrolysis, a highly efficient electrochemical reaction using electricity to break down water ( $H_2O$ ) into its constituent elements, hydrogen ( $H_2$ ) and oxygen ( $O_2$ ).**

The core components of an electrolyzer are cell stacks containing two electrodes through which electricity enters and exits the system, separated by a membrane across which the current passes. When electricity is applied to the system, hydrogen is formed at the cathode, oxygen at the anode. The membrane effectively keeps the gasses separate while they are harvested.

Hydrogen can be captured as a gas at extremely high purities, leaving oxygen that can be used for other purposes including industrial and medical uses. The hydrogen gas can be easily stored as a compressed gas or liquid.



## ELECTROLYZER EFFICIENCY

### MEASUREMENT

Energy experts like to express the efficiency of electrolyzer products as one single percentage (%) value. Hydrogen experts prefer to express electrolyzer efficiency in kilowatt-hours per kilogram (kWh/kg) for two reasons. Firstly, as an electrolyzer uses energy to generate hydrogen, the efficiency can be expressed as the ratio between electrical energy input and energy output (hydrogen). Secondly, the energy content of hydrogen is 33.3 kWh per kilogram, compared to 39.4 kWh at a high heating value.

### COMPARING EFFICIENCY

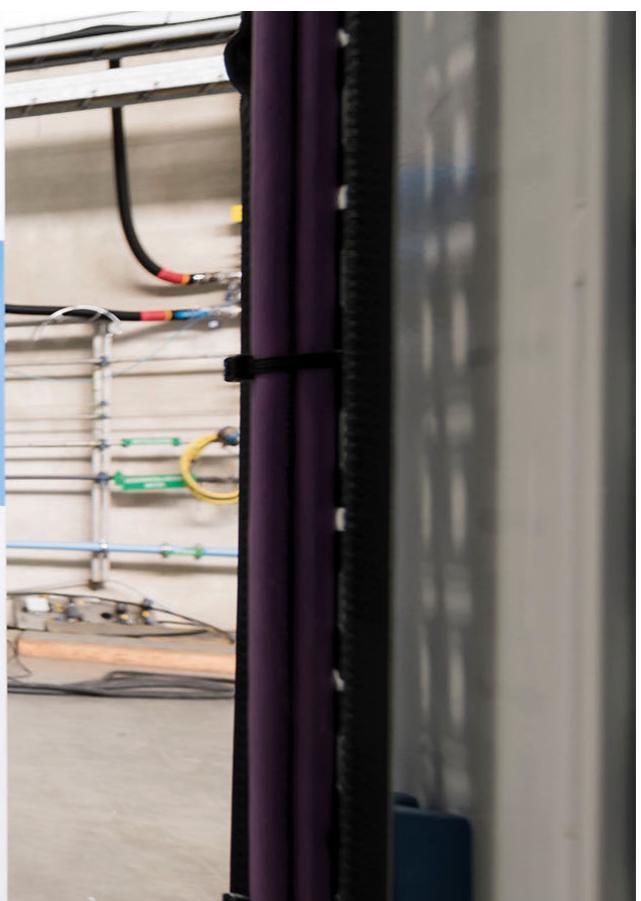
The power consumption of an electrolyzer depends on the exact scope of supply. To allow a fair comparison between various products, the scope of supply (cells stacks, balance-of-stack,

balance-of-plant), hydrogen output pressure (in bar) and hydrogen purity (in %), need to be the same.

Consumption will also vary over time – electrolyzers will consume less energy at the beginning of life (BOL) and more energy at the end of life (EOL) – and, over the operating window of the electrolyzer – electrolyzers will be more efficient at partial load (50%) than at nominal load (100%).

Efficiency values for Cummins electrolyzer products are expressed at the product boundaries, at rated pressure, nameplate capacity, hydrogen purity and at the BOL.

Cummins electrolyzer efficiency degrades by less than 1% per year (assuming 8,500 hours of annual operation). After 80,000 hours, stacks can be easily refurbished to as-new efficiency.



# PEM TECHNOLOGY

Proton Exchange Membrane (PEM) is the most robust and efficient technology for pure hydrogen generation at scale. Cummins is the industry benchmark for safe, widely proven PEM systems, delivering productivity and return on investment (ROI) beyond our competitors. Our ‘plug-and-play’ systems arrive onsite ready to safely and reliably produce very high purity hydrogen, continuously or flexibly, indoors, or out.

High efficiency aligns with low maintenance needs, delivering low capital and operational expense, with modularity that allows for simple scaling. Cummins systems connect to standard power and water connections and come equipped with standard water purification, power conditioning, hydrogen purification and remote servicing.

## MEGAWATT SCALE STACKS

Industry-leading 2.5 MW stacks, highly scalable for larger demands.

## EXCEPTIONALLY COMPACT

Industry-leading design – lower land, site preparation and building costs and shorter installation time.

## RESPONSIVE

Ultrafast responses to changes in hydrogen demand or power input.

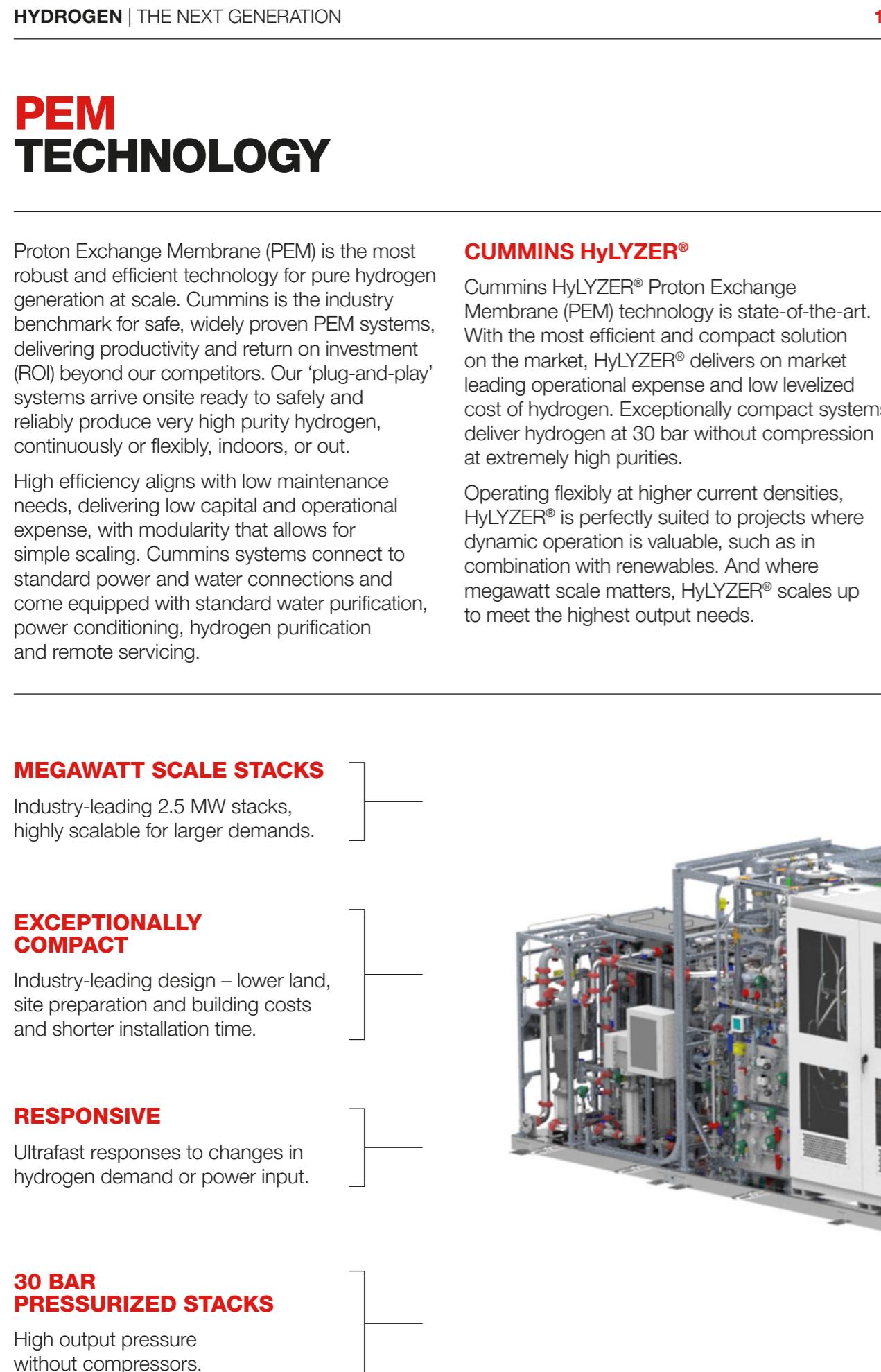
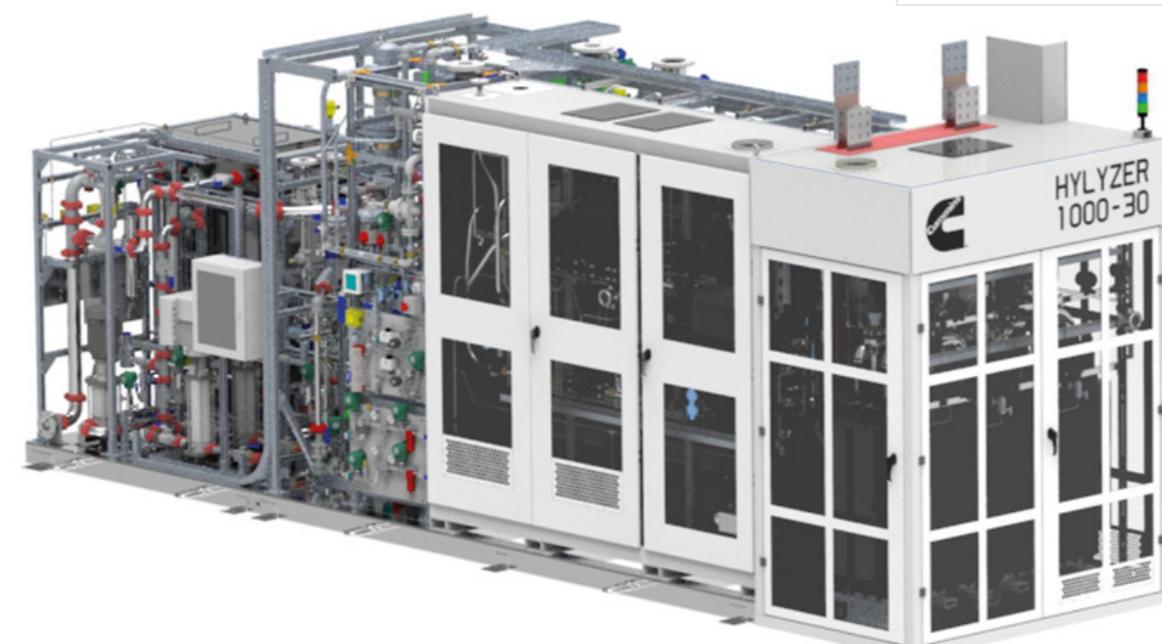
## 30 BAR PRESSURIZED STACKS

High output pressure without compressors.

## CUMMINS HyLYZER®

Cummins HyLYZER® Proton Exchange Membrane (PEM) technology is state-of-the-art. With the most efficient and compact solution on the market, HyLYZER® delivers on market leading operational expense and low levelized cost of hydrogen. Exceptionally compact systems deliver hydrogen at 30 bar without compression at extremely high purities.

Operating flexibly at higher current densities, HyLYZER® is perfectly suited to projects where dynamic operation is valuable, such as in combination with renewables. And where megawatt scale matters, HyLYZER® scales up to meet the highest output needs.



## PEM Electrolyzers | HyLYZER® Series

Product	H2 Flow (Nm³/h)	System efficiency (kWh/kg)	Equivalent power rating (MW)*	Output pressure (bar)	Outdoor / Indoor	Size Process module	Size Power module
HyLYZER® 200-30	200	≤ 55	1	30	Outdoor	40ft container	20ft container
HyLYZER® 250-30	250	≤ 55	1,25	30	Outdoor	40ft container	20ft container
HyLYZER® 400-30	400	≤ 54	2	30	Outdoor	40ft container	40ft container
HyLYZER® 500-30	500	≤ 54	2,5	30	Outdoor	40ft container	40ft container
HyLYZER® 1000-30	1000	≤ 51	5	30	Indoor	27.7ft x 7.5ft 8.5m x 2.3m	14.8ft x 8.2ft 4.5m x 2.5m
HyLYZER® 4000-30	4000	≤ 51	20	30	Indoor	50ft x 25ft 15.2m x 7.5m	23ft x 30ft 7m x 9m

The standard scope of supply for our electrolyzers differs between the outdoor and indoor products.

	Outdoor	Indoor
<b>STACK AND BALANCE-OF-STACK (BOS)</b>		
Cell stacks and Gas Generation System	*	*
Power rectifiers	*	*
Control Panel	*	*
Water quality monitoring system	*	*
Rectifier Cooling	*	*
<b>BALANCE-OF-PLANT (BOP)</b>		
Gas Cooling with Chiller	*	
Electrolysis Cooling with Dry Cooler	*	
Water Purification System	*	
Instrument Air Compressor	*	
Hydrogen Purification System	*	*

## LONG, MAINTENANCE-FREE LIFECYCLE

Limited and optimized maintenance, minimal degradation, 80,000 hours between stack membrane refurbishments; fast stack swap-out when required.

## HIGH EFFICIENCY AND ADVANCED CONTROL SYSTEMS

Lower power usage and low annual maintenance costs, with integrated safety sensors for safe plant operations.

\* = standard

\* for the indicative power rating, a standard efficiency value of 5 kWh/Nm<sup>3</sup> has been used across all products to give an indication of the product power rating. Our products are designed to supply a nominal hydrogen flowrate during its expected lifetime. In practice, our electrolyzers will consume less energy at the beginning of life (BOL) and more energy at the end of life (EOL) for a specific hydrogen production.

1kg of hydrogen is equivalent to 11,126 Nm<sup>3</sup> (volume of hydrogen under normalized conditions of 1 atmosphere and 0°C).

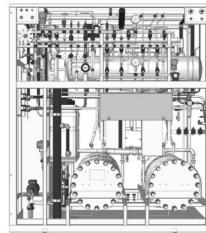
## ALKALINE TECHNOLOGY

This long-standing technology is based on Cummins proprietary IMET membrane, offering best-in class systems with the strongest safety record and reliability in the market.

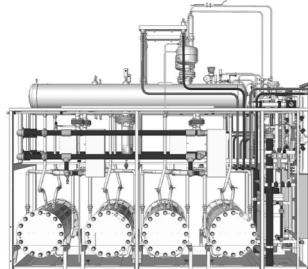
### CUMMINS HySTAT®

HySTAT® is Cummins globally proven modular alkaline electrolyzer system designed for easy

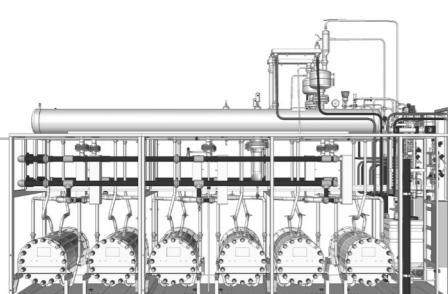
onsite installation inside or out, with simple interconnectivity to scale up, and an unrivalled record for reliability, low maintenance and onsite safety.



**Up to 2 cell stacks** 30 Nm<sup>3</sup>/h.



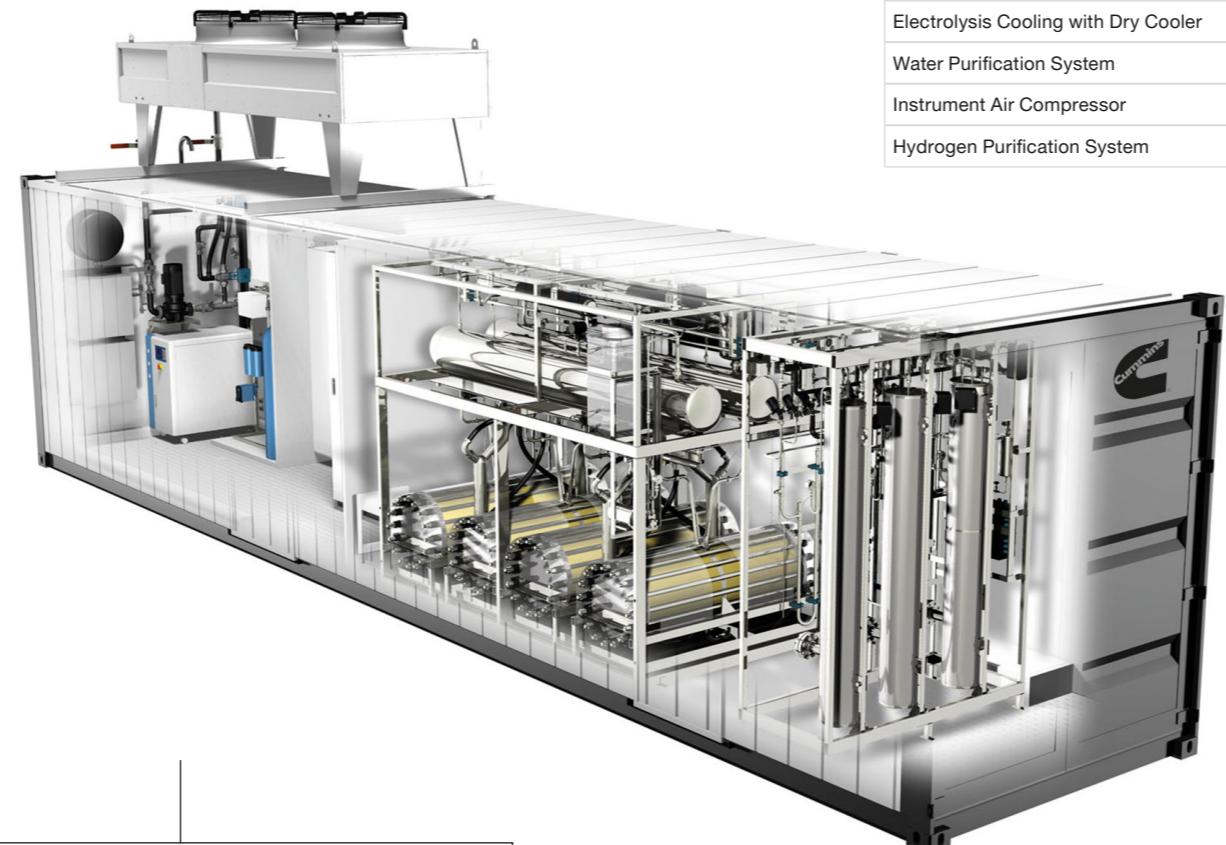
**Up to 4 cell stacks** 70 Nm<sup>3</sup>/h.



**Up to 6 cell stacks** 100 Nm<sup>3</sup>/h.

### PROVEN DURABILITY

Robust technology and long lifetime with minimal maintenance.



### ROBUST PROVEN TECHNOLOGY

Over 500 pressurized alkaline installations worldwide.

\* = standard

\* for the indicative power rating, a standard efficiency value of 5 kWh/Nm<sup>3</sup> has been used across all products to give an indication of the product power rating. Our products are designed to supply a nominal hydrogen flowrate during its expected lifetime. In practice, our electrolyzers will consume less energy at the beginning of life (BOL) and more energy at the end of life (EOL) for a specific hydrogen production.

1kg of hydrogen is equivalent to 11,126 Nm<sup>3</sup> (volume of hydrogen under normalized conditions of 1 atmosphere and 0°C).

### Alkaline Electrolyzers | HySTAT® Series

Product	H2 Flow (Nm <sup>3</sup> /h)	System efficiency (kWh/kg)	Indicative power rating (kW)*	Output pressure (bar)	Outdoor / Indoor	Size
HySTAT® 10-10	10	55-60	50	10	Outdoor & Indoor	20ft container
HySTAT® 15-10	15	55-60	75	10	Outdoor & Indoor	20ft container
HySTAT® 30-10	30	55-60	150	10	Outdoor & Indoor	20ft container
HySTAT® 60-10	60	55-60	300	10	Outdoor & Indoor	40ft container
HySTAT® 70-10	70	55-60	350	10	Outdoor & Indoor	40ft container
HySTAT® 100-10	100	55-60	500	10	Outdoor & Indoor	40ft container

The standard scope of supply for our electrolyzers differs between the outdoor and indoor products.

	Outdoor	Indoor
<b>STACK AND BALANCE-OF-STACK (BOS)</b>		
Cell stacks and Gas Generation System	*	*
Power rectifiers	*	*
Control Panel	*	*
Water quality monitoring system	*	*
Rectifier Cooling	*	*
<b>BALANCE-OF-PLANT (BOP)</b>		
Gas Cooling with Chiller	*	*
Electrolysis Cooling with Dry Cooler	*	*
Water Purification System	*	*
Instrument Air Compressor	*	*
Hydrogen Purification System	*	*

### MODULAR AND FLEXIBLE

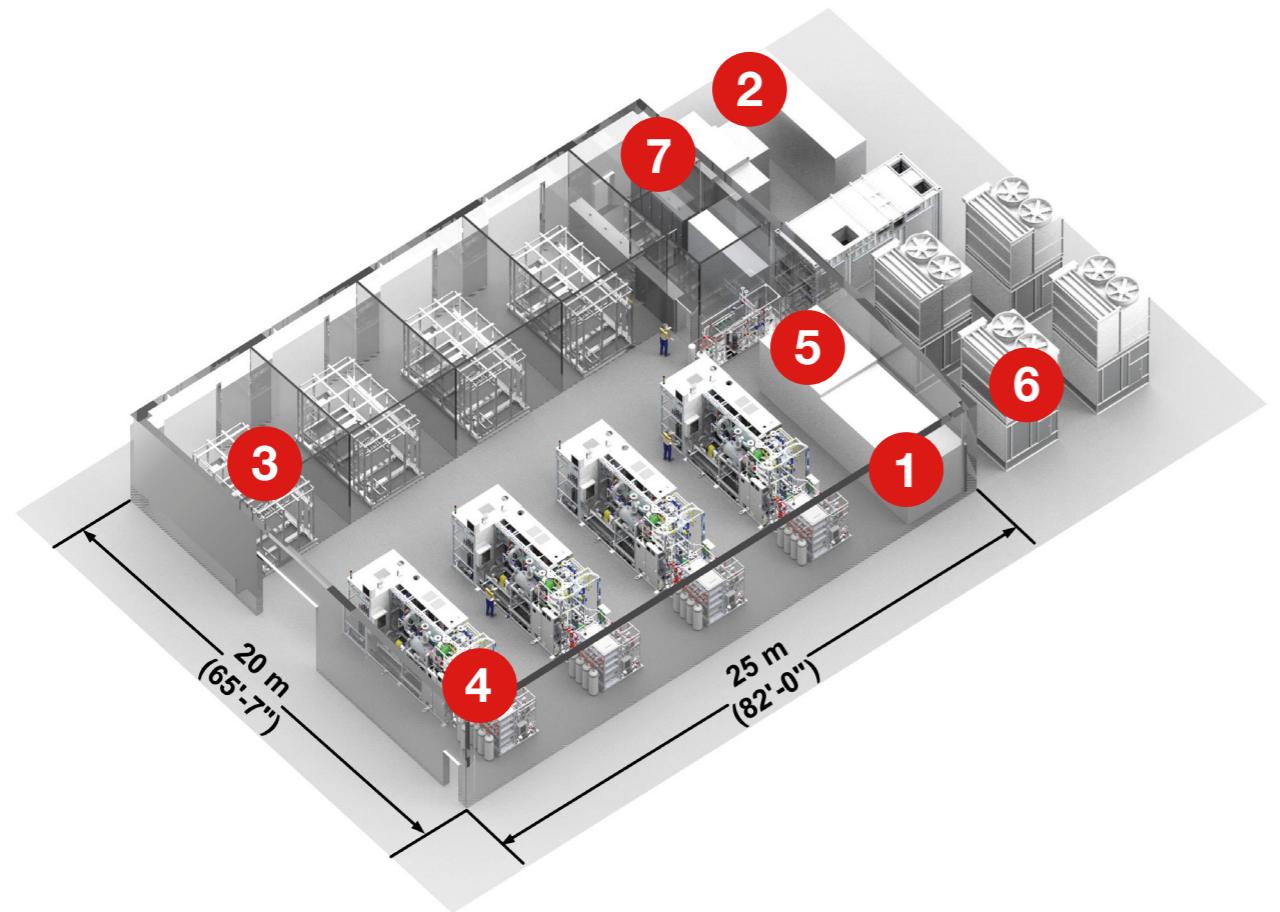
Stack configurations available in 1, 2, 4 and 6 stacks with nominal hydrogen outputs from 10 to 100 nm<sup>3</sup>/h, easily scalable to future needs.

### SAFE

Flawless safety record over decades.

## PIONEERING HYDROGEN AT SCALE

Taking hydrogen power generation to megawatt scales and beyond is a complex technical challenge. At Cummins, we're proud to lead the way. We were the first to achieve MW scale, and today, we're setting records with some of the largest plants in the world. If scale is your goal, no one understands it better.



- 1 Central water purification system** Converts tap water into clean de-ionized water suitable for the cell stacks.
- 2 Electrical substation** Transformer and switchgear where high voltage from the grid is converted to medium voltage AC.
- 3 Rectifier and transformer** Medium voltage AC is converted into DC power for the cell stacks.
- 4 Electrolyzer system** Breaks water molecules into hydrogen gas and oxygen gas, separated from water in gas-liquid separators. Enclosed, monitored and

- ventilated hydrogen production means building does not need to be classified as a hazardous area. The result: 99.99% pure hydrogen produced at 30 bar.
- 5 Optional hydrogen purification system** If required, hydrogen can be further purified to fuel cell quality (99.998%).
- 6 Central cooling system** Cools water circulating through the cell stacks to optimize electrolysis efficiency.
- 7 Control room** Centralized plant logic and safety control system.

## CUMMINS PEM TECHNOLOGY AT SCALE BÉCANCOUR, QUEBEC

**Cummins technology powers the largest PEM electrolyzer in operation in the world.**

Installed at the Air Liquide hydrogen production facility in Bécancour, Quebec, the 20 MW Cummins electrolyzer system can produce over 3,000 tons of hydrogen annually using clean hydropower.

The modular and scalable electrolyzer platform addresses utility-scale hydrogen production.



## HELPING TO BUILD A GREEN ECONOMY

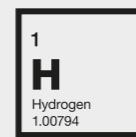
### WORLD'S FIRST MEGAWATT-SCALE POWER-TO-GAS PROJECT

#### FALKENHAGEN, GERMANY

At the first demonstration plant for storing wind energy in the natural gas grid, around 360 Nm<sup>3</sup>/h of hydrogen is generated by six Cummins HySTAT® 60-10 electrolyzers. The hydrogen generated is fed via a pipeline into the gas grid. The energy is available to the electricity, heating, mobility, and industrial market when required, just like normal natural gas. In the first year of operation, more than 2 million kWh of hydrogen ("WindGas") were fed into the gas grid.



360 Nm<sup>3</sup>/h of hydrogen generated by 6 Cummins HySTAT® 60-10 electrolyzers.



In the first year of operation, more than 2 million kWh of hydrogen were fed into the gas grid.



### HYDROGEN REFUELING ABERDEEN, SCOTLAND

Cummins supplied the HySTAT 60® electrolyzer for the Aberdeen City Hydrogen Energy Storage (ACHES) facility. The facility offers hydrogen refueling for cars, vans, trucks and buses. The station has multiple electric recharging points and has the potential to produce 130kg of hydrogen per day. To enable fast refueling, hydrogen is dispensed at 350 bar and 700 bar pressure.



The refueling station is capable of producing up to 130 kg of 99.999% pure hydrogen per day.



Refueling for cars, vans, trucks and buses



## EXPERIENCE MEETS INNOVATION

With the acquisition of Hydrogenics in 2019, Cummins became one of the world's leaders in hydrogen generation and fuel cell development. No one else combines cutting-edge expertise in hydrogen generation with the manufacturing

scale, global support network and century-long experience of the Cummins corporation. No one is better equipped to support your hydrogen ambitions.

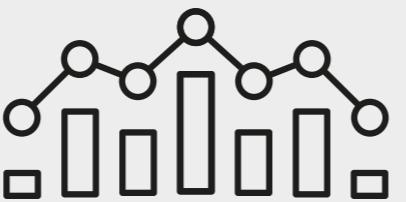
**190**  
countries



Pioneering the world's largest scale PEM electrolyzer installation

**\$1bn**

annual spend to advance power technologies



**70+**

years of hydrogen expertise

**600+**

electrolyzers systems installed worldwide



# **ALWAYS INNOVATING FOR A WORLD THAT'S ALWAYS ON**

Find out more at  
**cummins.com/hydrogen**  
**WE'RE READY. TODAY.**



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